AIR QUALITY MONITORING CONSIDERATIONS FOR THE CUMBERLAND/PIEDMONT NETWORK

ALABAMA, GEORGIA, KENTUCKY, AND TENNESSEE UNITS

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Introduction

The NPS Air Resources Division (ARD) has contracted with the University of Denver (DU) to produce GIS-based maps that estimate baseline values (with confidence limits) for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. ARD used the DU products to help develop an implementation strategy for expanding NPS air quality monitoring under the Natural Resources Challenge. Based on the implementation strategy, ARD intends to fund installation of a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) wet deposition monitor, a Clean Air Status and Trends Network (CASTNet) dry deposition monitor, and a wet mercury deposition network monitor at Mammoth Cave National Park (NP) in FY 2002. At this time, ARD does not intend to fund additional monitoring at any NPS units in the Cumberland/Piedmont Network. The air monitoring implementation strategy will be revisited in FY 2004 if additional funding becomes available. The Cumberland/Piedmont Network can use the DU products (which will be available on the NPS Intranet site over the next few months at http://www2.nrintra.nps.gov/ard/ under "Air Atlas"), along with ambient monitoring and natural resource data discussed in this report, to help assess air quality-related conditions and monitoring needs in Network parks.

Wet Deposition

None of the nine NPS Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, or Tennessee currently have a NADP/NTN wet deposition monitor on-site, but eight units have a monitor within 100 km (60 miles). The closest NADP/NTN monitor to Stones River National Battlefield (NB) is about 180 km (110 miles) northwest of the park. Placing a monitor at Mammoth Cave NP will add a site 140 km (85 miles) north of the park. NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, wet deposition and concentration of sulfate is higher in the eastern than in the western U.S. In 2000, as in previous years, wet concentration and deposition of both sulfate and nitrate were moderate to high in northern Alabama and Georgia, western Tennessee, and Kentucky. Wet concentration of ammonium was low, and wet deposition of ammonium was moderate. (see U.S. wet deposition and concentration isopleth maps at http://nadp.sws.uiuc.edu). Data from NADP/NTN sites near Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee are summarized below.

Crossville, AL

The Crossville, Alabama, NADP/NTN site (site #AL99 (Sand Mountain Experiment Station)) was installed in 1984. Wet concentration and deposition of sulfate have decreased at the site, while wet concentration of ammonium, wet concentration of nitrate, and wet deposition of nitrate have increased. There has been no overall trend in wet ammonium deposition.

Land Between the Lakes, KY

Land Between the Lakes, Kentucky, has had a NADP/NTN site (site #KY99) since 1994. To date, site data have not met the completeness criteria required for NADP/NTN to perform trend analyses.

Mackville, KY

An NADP/NTN site was installed at Mackville, Kentucky, (site #KY03) in 1983. Site data show a decrease in wet sulfate concentration, and an increase in wet ammonium deposition. There has been no overall trend in wet sulfate deposition, wet ammonium concentration, wet nitrate deposition, and wet nitrate concentration.

Hatchie National Wildlife Refuge, TN

The Hatchie National Wildlife Refuge, Tennessee, NADP/NTN site (site #TN14) has been in operation since 1984. The site data show a decrease in deposition of wet sulfate; an increase in concentration of wet ammonium; an increase in concentration of wet nitrate; and no overall trend in concentration of wet sulfate, deposition of wet nitrate, and deposition of wet ammonium.

Oak Ridge National Laboratory, TN

The Oak Ridge National Laboratory, Tennessee, NADP/NTN site (site #TN00 (Walker Branch)) has been in operation since 1980. The site data show a decrease in concentration of wet sulfate, but no apparent trend in deposition of wet sulfate. There has been an increase in wet ammonium concentration, wet ammonium deposition, and wet nitrate deposition, but no apparent trend in wet nitrate concentration.

Speedwell, TN

The NADP/NTN site was installed at Speedwell, Tennessee, (site #TN04) in 1999. Sufficient data are not yet available to characterize pollutant trends at the site.

While there is a lot of variability between sites, in general, trends in wet sulfate concentration and deposition at NADP/NTN sites in the area are either stable or decreasing, while trends in wet nitrate and ammonium concentration and deposition are either stable or increasing.

Based solely on spatial distribution, it appears Stones River NB is probably not well represented by existing NADP/NTN sites. Addition of the NADP/NTN monitor at Mammoth Cave NP may provide better coverage for Stones River NB. Cost information is provided in case the Network is interested in installing a site at the park. A NADP/NTN wet deposition site costs $5,000 to $8,000 for equipment purchase and

installation, and operating costs (including site operation, chemical analysis, and reporting) are about $7,000 per year.

Dry Deposition

None of the nine NPS Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, or Tennessee have a Clean Air Status and Trends Network (CASTNet) dry deposition monitor on-site, but seven units have a monitor within 120 km (70 miles). The closest monitors to Fort Donelson NB and Shiloh National Military Park (NMP) are 185 km and 175 km, respectively (about 105 miles). CASTNet uses different monitoring and reporting techniques than NADP/NTN, so the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected near Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee are summarized below.

Crossville, AL

The Crossville, Alabama, CASTNet site (site #SND152 (Sand Mountain Experiment Station)) has been in operation since 1988. There has been a decrease in dry sulfur deposition at the site, but no trend in dry nitrogen deposition. Total nitrogen deposition at the site is composed of 36 percent dry deposition and 64 percent wet deposition, while total sulfur deposition is 41 percent dry and 59 percent wet.

Mackville, KY

A CASTNet site has been operating at Mackville, Kentucky, (site #MCK131) since 1990. Site data indicate a decrease in dry sulfur deposition, but no trend in dry nitrogen deposition. CASTNet estimates total nitrogen deposition at the site is composed of 38 percent dry deposition and 62 percent wet deposition, while total sulfur deposition is 50 percent dry and 50 percent wet.

Coffeeville, MS

A CASTNet site has been operating at Coffeeville, Mississippi, (site #CVL151) since 1988. While there has been no trend in dry sulfur deposition, dry nitrogen deposition increased through 1995, and then leveled off. CASTNet estimates total nitrogen deposition at the site is composed of 31 percent dry deposition and 69 percent wet deposition, while total sulfur deposition is 23 percent dry and 77 percent wet.

Edger Evins State Park, TN

A CASTNet site has been operating at Edger Evins State Park, Tennessee, (site #ESP127) since 1988. Site data show a decrease in dry sulfur deposition, but no trend in dry nitrogen deposition. CASTNet estimates total nitrogen deposition at the site consists of 25 percent dry deposition and 75 percent wet deposition, while total sulfur deposition is 24 percent dry and 76 percent wet.

Speedwell, TN

The Speedwell, Tennessee, CASTNet site (site #SPD111) has been operating since 1989. A review of the site data shows no apparent trend in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at Speedwell consists of 28 percent dry deposition and 72 percent wet deposition, while total sulfur deposition is 39 percent dry and 61 percent wet.

Based solely on spatial distribution, it appears that Fort Donelson NB and Shiloh NMP are not well represented by existing CASTNet sites, and installation of a dry deposition site at Mammoth Cave NP will not improve coverage. If the Network chooses to install a new site, installation and annual operating costs for a CASTNet site are about $50,000 and $15,000, respectively.

Surface Water Chemistry

The Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for six of the nine Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee. Data from those reports are summarized below. In general, acid-sensitive surface waters have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l).

Abraham Lincoln Birthplace NHS

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Abraham Lincoln Birthplace National Historic Site (NHS) showed limited surface water quality data were collected at springs in the park, including Sinking and Boundary Oak Springs, between 1960 and 1997. The pH values averaged about 7. 7 and ANC values were about 1400 μeq/l. These data indicate springs in the park are well buffered against acid deposition.

Chickamauga and Chattanooga NMP

A review of the 2001 *Baseline Water Quality Data Inventory and Analysis* report for Chickamauga and Chattanooga NMP showed limited sampling has taken place inside the park. Chickamauga Creek was sampled four times between 1967 and 1980. The average pH value was 7.6 and the average ANC was 944 μeq/l. Skyuka Spring was sampled once in 1992, and had a pH of 7.6 and an ANC of 720 μeq/l. All other sites sampled in park are caves, which are well buffered. Outside the park, Chickamauga Creek was sampled from 1974 to 1995, and samples had an average pH of 7.6 and an average ANC of 928 μeq/l. Chattanooga Creek was sampled from 1982 to 1998, and had an average pH of 7.1 and an average ANC of 800 μeq/l. These data indicate surface waters in the area are not sensitive to acidification from atmospheric deposition.

Fort Donelson NB

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Fort Donelson NB showed that no water quality data had been collected in the park and that few data are available for the area. Therefore, it is not possible to assess the sensitivity of park surface waters to acid deposition.

Russell Cave NM

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Russell Cave National Monument (NM) showed that a couple of water quality samples were collected at Bridgeport, Tanyard, Blue, and Crownover Springs between 1971 and 1986. The average pH values ranged from 6.7 to 7.8 and the ANC values ranged from 568 to 1280 μeq/l. Although the data are limited, they indicate springs in the park are not sensitive to acidification from atmospheric deposition.

Stones River NB

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Stones River NB showed that one site in the park, McFadden Spring, was sampled in 1975, and that no data had been collected outside the park since 1986. The sample from McFadden Spring had a pH of 6.7 and an ANC value of 2040 μeq/l. Samples from Lytle Creek, Fox Camp Spring Creek, Oakland Springs, Military Springs, and Stones River had pH values ranging from 7.2 to 8.0 and ANC values ranging from 320 to 2064 μeq/l. While these data indicate surface waters in the area are not sensitive to acidification from atmospheric deposition, it is desirable to confirm this with data that are more recent.

Little River Canyon NPres

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Little River Canyon NPres showed that samples were collected at a number of locations along the Little River between 1967 and 1998. Average pH values ranged from 5.8 to 6.5, while average ANC values ranged from 18 to 144 μeq/l. Minimum ANC values ranged from 0 to 56 μeq/l. These data indicate the Little River is very sensitive to acidification from atmospheric deposition.

Visibility

Visibility-impairing particles and certain gases are monitored in natural areas through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Because of the mandates of the Clean Air Act, the IMPROVE program has focused monitoring efforts in Class I air quality areas, such as Mammoth Cave and Great Smoky Mountains NPs. Regardless, IMPROVE monitoring provides a regional analysis of visibility; therefore, the data indicate conditions in nearby Class II air quality areas. IMPROVE program staff recently identified an error in past data calculations and are in the process of re-calculating the data. Therefore, trend data are not currently available for IMPROVE sites. All Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, and Tennessee have an IMPROVE monitor within 175 km (about 100 miles). The four IMPROVE sites in the region are Mammoth Cave NP, Kentucky (site #MACA1; operating since 1991), Great Smoky Mountains NP, Tennessee (site #GRSM1; operating since 1988), the Sipsey Wilderness Area, Alabama (site #SIPS1; operating since 1992), and the Cohutta Wilderness Area, Georgia (site #COHU1; new site).

Based solely on spatial distribution, it appears existing IMPROVE sites provide adequate coverage for Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and

Tennessee. Installation and annual operating costs for an IMPROVE site are about $15,000 and $30,000, respectively.

Ozone

One of the Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee has an ozone monitor on-site (Mammoth Cave NP, site #210610501), and all but one of the others have a monitor within 45 km (about 25 miles). The closest ozone monitor to Little River Canyon NPres is in Chattanooga, Tennessee, about 75 km (45 miles) away. Based solely on spatial distribution, it appears that Little River Canyon NPres may not be well represented by existing ozone monitors. Installation and annual operating costs for an ozone monitoring site are about $90,000 and $14,000, respectively. According to a map generated by DU, all nine Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee are likely to have exceedances of the human health-based 8-hour National Ambient Air Quality Standard.

Vegetation

For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than either sulfur dioxide or nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Park vascular plant lists contained in a May 2001 version of NPSpecies were compared to the general ozone-sensitive plant species lists contained in the NPS Synthesis information management system (see attached Synthesis species lists). The Synthesis lists were developed by an expert in the field of ozone effects on vegetation. Note that the Synthesis lists are a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. Ozone sensitive species of natural vegetation were identified for all nine Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee (see attached tables of sensitive species for Network parks).

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is the SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.06 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06 effects endpoints for natural vegetation, i.e., 8 to12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. According to a SUM06 map generated by DU, all nine Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee have ozone concentrations, during some years, that are high enough to harm native vegetation. Given this, Network staff may want to conduct foliar injury surveys on sensitive species. Such surveys have been conducted in nearby Great Smoky Mountains NP for a number of years. Good survey species are black cherry (*Prunus serotina*) and common milkweed (*Asclepias syriaca*) because 1) ozone injury symptoms for these species are well described and 2) standardized survey protocols and training manuals have been developed.

Conclusions

Eight of the nine NPS Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, and Tennessee have a NADP/NTN wet deposition monitor within 100 km (60 miles). Planned installation of a monitor at Mammoth Cave NP in FY2002 will add a site 140 km (85 miles) north of Stones River NB. The Mammoth Cave NP monitor may provide adequate coverage for Stones River NB.

Seven of the nine Cumberland/Piedmont parks in Alabama, Georgia, Kentucky, and Tennessee have a CASTNet dry deposition monitor within 120 km (70 miles). Based solely on spatial distribution, it appears that Fort Donelson NB and Shiloh NMP may not be well represented by existing CASTNet sites. Given the high cost of dry deposition monitoring and the fact that both parks have nearby wet deposition monitoring, installation of a dry deposition monitor is not recommended.

A review of water quality data indicates surface waters at Abraham Lincoln Birthplace NHS, Chickamauga and Chattanooga NMP, and Russell Cave NM are not susceptible to acidification from atmospheric deposition. More data are desirable to confirm that surface waters at Stones River NB are well buffered against acidification. The sensitivity of surface waters at Fort Donelson NB is not known. Data indicate the Little River at Little River Canyon NPres is very sensitive to acidification from atmospheric deposition. Long-term monitoring of both pH and ANC in the Little River is recommended.

All of the Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, and Tennessee have an IMPROVE visibility monitor within 175 km (about 100 miles). Based solely on spatial distribution, this coverage appears adequate for the parks.

Eight of the Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee have an ozone monitor within 45 km (about 25 miles). Based solely on spatial distribution, it appears that Little River Canyon NPres may not be well represented by existing ozone monitors. DU has not yet finished determining confidence limits for the baseline values they calculated for the Inventory and Monitoring parks; in other words, they have not yet assessed how well the calculated values actually represent conditions in the parks. When DU finishes this part of the project, both ARD and the Cumberland/Piedmont Network will have more information about the need for ozone monitoring at Little River Canyon NPres. It is likely that all nine parks Cumberland/Piedmont Network parks in Alabama, Georgia, Kentucky, and Tennessee have exceedances of the human health-based 8-hour National Ambient Air Quality Standard.

Ozone sensitive species have been identified for all nine Cumberland/Piedmont Network units in Alabama, Georgia, Kentucky, and Tennessee. Ozone concentrations are high enough in all nine units to warrant foliar injury surveys.

Relevant Websites

NADP - http://nadp.sws.uiuc.edu/
CASTNet - http://www.epa.gov/castnet/

IMPROVE - http://vista.cira.colostate.edu/improve/
Ozone - http://www.epa.gov/air/data/sources.html
Pollution sources and air quality data - http://www.epa.gov/air/data/index.html
Ozone-specific sources and data - http://www.epa.gov/ttn/rto/areas/
Pollution source and air quality graphics - http://www.epa.gov/agweb/
Air toxics - http://www2.nature.nps.gov/ard/aqmon/air_toxics/